Parameterized Kick Engine For R-SCUAD *Robot*

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Abstract—Humanoid Robot Soccer is an implementation of technology in robotics area that has the ability to mimic human activity to play football. Kicking is one of many abilities that the robot must have to play football nicely. The ability to kick in a various kind of kick also needed to enhance it's performance in the match.This research was conducted on a 20 degree of freedom humanoid robot soccer named R-SCUAD. The robot was equipped with 20 Dynamixel servo motors as the actuator, an arbotix-pro as a sub-controller and an Odroid XU4 as the main controller. The method developed in this research was based on Darwin-op framework with an enhancement especially on the kick engine. Experiment results showed that there was a corellations between the distance that the ball travelled due to a kick with leg the swing speed of the kick, it can be inferred that a greater swing speed value will yields a greater distance of ball travel. With the leg swing speed of 50 rpm generate average distance 36.58 cm while with a speed of 300 rpm generate an average distance of 329.62 cm. Result also showed that the balancing system developed based on kick angle computation was able to maintain the robot stability up to 25 ° of kick angle.

Keywords; Forward kinematics; Humanoid robot soccer; Parametric kick;

I. Introduction

Indonesian Robocup Socccer Humanoid League was the new title for Kontes Robot Cerdas Indonesia (KRCI) *Robo Soccer Humanoid League* (RSHL) that became an event to select Indonesia's reperesentative for the Robocup Intenational yearly event. *Humanoid Robot Soccer* was a form of technological implementation in the robotic field that has the ability to mimic human's activities in playing football/soccer. [1].

The robot also must posses an ability to "hear" referee's instructions, in this case using a wifi network communication system. The robot must have the ability to percept the field and all form of object that may present on the field. The Robot must walk on biped while maintaining its balance so it can locomote reliably. Many researchers try to cope this problem in their research, such as [2-6] . Those research aimed to have a better walking capabilities for the robot. This research mainly based on the research of Darwin-op framework [2], that propose an approach to have a robot that has the ability to walk, kick and do some kind of movement based on input from the USB camera attached to the robot.

To achieve those kind of abilities, the robot equipped with a configuration of component and hardware that enable the robot to move freely and achieve high level of dynamics. Inside the robot's torso an embedded pc was placed as the main controller, the sub controller was stacked on the mani controller. As the actuation the robot uses 20 pieces Dynamixel servo, webcam was used as the vision sensory input to get information from its surrounding. A 3 axis Gyroscope and 3 axis accelerometer also attached to the robot as its internal state sensory input. This research was focused on how to develop a parametric kick engine that enables the robot to has an infinite variations of kick motion. The Darwin-op framework already has an ability to do kicking motions, but it uses a prerecorded handcrafted motion. In other word we would have to create every single type of kick or motion manually by hand, if we want to have a variety of kick. It was a very time consuming task to craft this kind of motions because we need to manually adjust the positions of every joint, record those posisition as pose, proceeded with altering some joint to have a movement, record as another pose, one after another and save those pose as a motion that could be called to be playback on the future.

This research was motivated by the need to develop a kick engine that not involving handcrafting a kicking motions as the original Darwin-op framework did. Ferreira Rui, [7] has done a research titled *Development of an Omnidirectional Kick for a NAO Humanoid Robot* in which the developed kick engine consist of 5 phase.

- Lean_Phase – This is when the robot shifts is center of mass onto support leg.
- Raise_Phase – Phase where the robot raises the kick foot off the ground.
- Kick_Phase – When the robot kicks the ball. This is the main phase.
- Return_Phase – Phase when the robot reurn the leg without putting the foot on the ground
- UnRaise_Phase – This is when the robot shifts is center putting the kick foot on the ground.

II. RESEARCH METHODOLOGY

A. *Hardware Configuration*

Generally speaking, the robot consist of *main control*, *sub control* and *actuator* , the robot's block diagram presented on figure number 1 below :

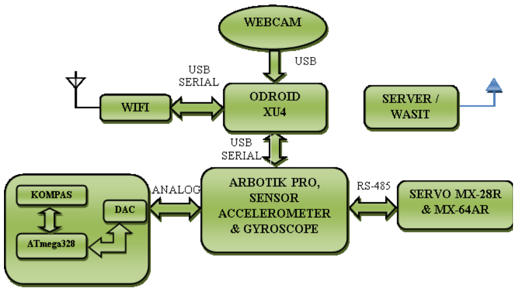

Figure 1 Robot's Block Diagram

The main controller was the Odroid XU4. It's an ARM based single board computer with a Samsung Exynos5422 Cortex-A15 2Ghz and Cortex-A7 Octa core CPUs as the main processor. We use Linux Ubuntu 14.04 for this research and C++ for the main programming language. OpenCV also installed on the main controller to utilize the library for the robot's vision system. Linux and android operating system for this board was made available by hardkernel as the creator of the board. As for the subcontroller we use a STM32 based controller, equipped with 3 axis gyroscope and 3 axis accelerometer and also the necessary circuitry needed to communicate to the Dynamixel MX series digital servomotor as the actuator. There R-SCUAD Robot used in this research, as shown in figure 2, use two kind of Dynamixel MX-series. The MX-64 and MX-28 series.

DYNAMIXEL (DXL) is a line-up of networked actuators for robots developed by a Korean manufacturer ROBOTIS. ROBOTIS is also the developer and manufacturer for DARwIn-OP[8]. DXL is being used by numerous companies, universities, and hobbyist due to its versatile expansion capability, powerful feedback functions, position, speed, internal temperature, input voltage, etc. It has a simple daisy-chain topology for simplified wiring connections.

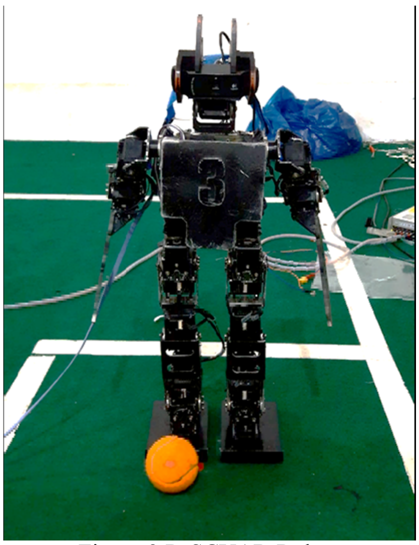

Figure 2 R-SCUAD Robot

DXL can be used for multi-joint robot systems such as robotic arms, robotic hand, bi-pedal robot, hexapod robot, snake robot scorpions, pan tilts, kinematic art, animatronics and automation, etc. Dynamixel is an actuator controlled by digital packet communication (protocol communication). User could send an instruction packet, in serial form, and the dynamixel will respond to the instruction accordingly.

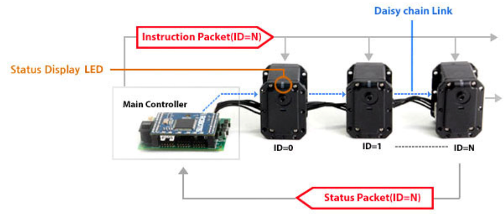

Figure 3 Dynamixel Communication Protocol

B. *Software Configuration*

The kick engine was developed based on forward kinematics, i.e. the system supplied with the joint position information and the final position of the link, the leg in this case was obtained. Simple balancing system based on the relation between kick angle and hand angle was added to kick engine. The balancing system will compute the necessary arm movement to encounter to force generated from opening the leg. The flowchart for the developed kick engine for the R-SCUAD can be depicted on the figure 4., below.

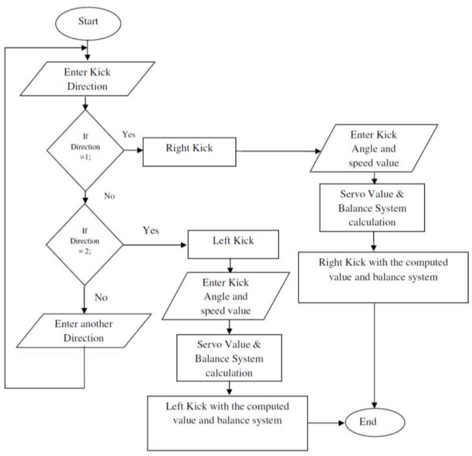

Figure 4 Flowchart of the developed kick engine

A kick consist of 5 phase that must be completed to have a kick.

- Lean
- Raise
- Kick
- Return
- UnRaise

Those stages can be depicted below

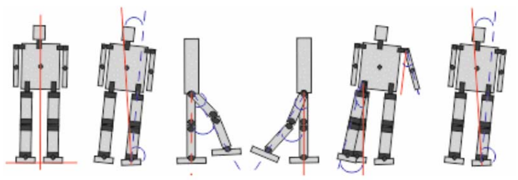

Figure 5 Kick Phase

III. RESULT AND ANALYSIS

There were two kind of testing in this research, first a test to verify distance traveled from a various kick swing speed, and the second was test to verify the robot stability for a numerous kind of kicking motions.

A. Ball Travel

As mentioned beforehand a kick consist of 5 phase, the implementation of those 5 phase can be seen on figure no 6 below

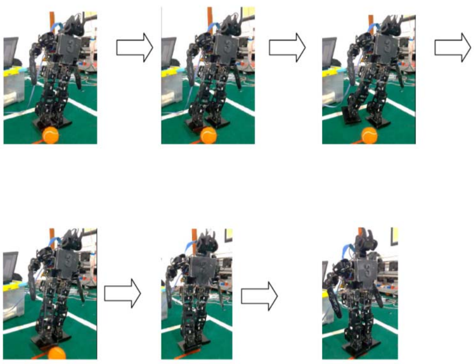

Figure 6 Kick Implementation

To verify that the kick engine developed has a controlling ability for ball travel distance, we conducted a series of test with the variation of kick swing speed. The result showed the relations between kick swing speed with the ball travel distance can be seen in figure 7 below

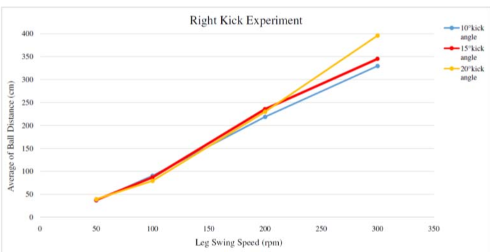

Figure 7 Ball Travel and Kick Speed

It can be inferred from the graph that the robot could control the ball travel distance proportionally with the kick swing speed for any given kick angle. Robot was able to kick the ball up to 3 m distance using 300 rpm kick speed.

B. Balancing Ability

The balancing test was conducted using variation of kick angle and swing speed parameter. The parameter will be used as reference on how far the balancing system able to maintain the robot in standing position, i.e. not fall. There are two kind of test here, right kick and left kick. As mentioned earlier the balancing system was implemented simply using the kick angle, how far is the kicking leg opened from its normal position. This value will be used to determine how far the arm will move or opened to encounter the leg movement. This process is done synchronously while opening the leg.

Data collected for 10°, 15°, 20°, 25° and 30° kick angle with 50, 100, 200, and 300 rpm kick speed, the result shown in figure no 8. below.

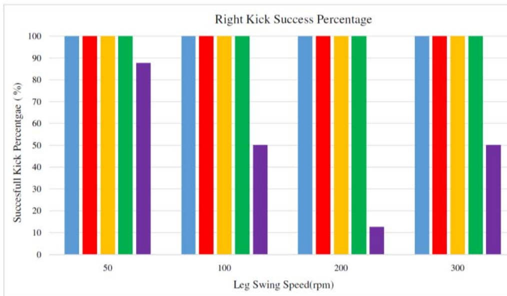

Figure 8 Succesful Kick Percentage (Right kick)

It can be seen from the graph that regarding right kick the robot has a very high percentage of successful kick motion for all kick swing speed, however there is a decrease in this percentage when we give a wider kick angle, in this case 30°.

Same procedure was taken for the left kick motion, the arm opening was done synchronously with the leg opening to maintain the robot's balance.

Data collected for 10°, 15°, 20°, 25° and 30° kick angle with 50, 100, 200, and 300 rpm kick speed, the result shown in figure no.8 below.

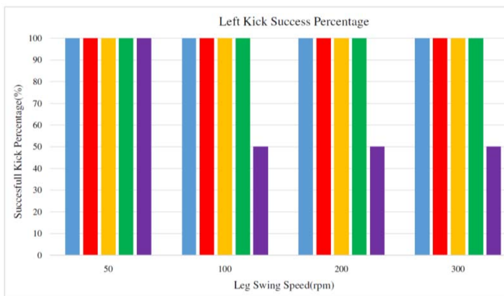

Figure 8 Succesful Kick Percentage (Left kick)

It can be seen from the graph that regarding left kick the robot has a very high percentage of successful kick motion for all kick swing speed, however there is a decrease in this percentage when we give a wider kick angle, in this case 30°.

IV. CONCLUSION

Based on experimental result, conclusions below could be inferred:

Kick variations were able to be implemented in the form of kick angle and kick swing speed parameter, these parameter were proportionally related to ball travel distance due to the kick. It were verified using 10°, 15° and 20° kick angle and 50, 100, and 200 rpm kick swing speed. The faster the kick swing the further the ball traveled. The developed balancing system was based on arm angle computation algorithm. The system was able to maintains the robot balance when performing a kicking motions. The developed balancing system still unable to guarantee a 100% secessful kick for 30° of kick angle. Gyroscope and Accelerometer stabilized kick engine should be investigated in the future to enhace the robot balancing ability when performing a kicking motions.

Acknowledgment

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